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DEPARTMENT OF COMMERCE

UNITED STATES BUREAU OF MINES
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INFORMATION CIRCULAR

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DAVID C. MINTON, JR.

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COST OF EQUIPPING AND DEVELOPING A SMALL GOLD MINE IN THE BRADSHAW MOUNTAINS QUADRANGLE, YAVAPAI COUNTY, ARIZ.[1]

By David C. Minton, Jr.[2]

INTRODUCTION

This paper describes in detail the cost of equipping and developing the Golden Belt mine, Yavapai County, Ariz. These costs should be typical of the average small gold mine in central Arizona which has been equipped with used machinery at a minimum of capital expenditure. The conditions of remoteness, transportation, water, and power supply are about average for properties in the Bradshaw Mountains and that vicinity. There are several mines in the district in the process of development and several dormant properties that might be opened in the future.

The Golden Belt group of claims was taken over by the present management in May, 1931. Although some active development has been carried on in recent years, resumption of work at the old property required entire rehabilitation of the equipment and camp. As the water level had not been reached, there was no problem of dewatering. In the presentation of costs in this paper an evaluation of the cost of equipment and development work as taken over by the Golden Belt Mines, Inc., has been made. Exact data, however, on previous exploration and construction costs are lacking. The total cost of equipping and developing the mine to its present stage has been obtained by adding the disbursements of the present management to the above-mentioned evaluation. These costs do not include the cost of replacing camp equipment destroyed by fires, of unsuccessful milling experiments, management, or obsolete equipment on the property.

The author acknowledges the courtesy of A. L. Lampton, president of Golden Belt Mines, Inc., in permitting the data in this paper to be published.

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1 The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6735."

2 One of the consulting engineers, U. S. Bureau of Mines.

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LOCATION

The Golden Belt mine is in the Black Canyon mining district, Yavapai County, Ariz., on the eastern slope of the Bradshaw Mountains at an elevation of approximately 3,100 feet. The camp is situated on Turkey Creek, 1½ miles west of the Black Canyon Highway, 2 miles east of Cleator (formerly Turkey Station), and 68 miles north of Phoenix. Mayer, a town on the highway and the A. T. & S. F. Railway 15 miles north of the camp, is the shipping point. Although climatic conditions are ideal for operation throughout the year, heavy rains and snows sometimes hamper transportation by truck. Concentrates are shipped to Mayer by truck in 3 to 4 ton loads, each truck making three round trips per shift. Supplies and equipment are trucked in from either Phoenix or Prescott. Hauling of both concentrates and supplies is done by company truck at a cost of approximately $0.05 per ton-mile.

WATER, POWER, AND FUEL

The water supply for the camp and mill is pumped from a well on the edge of Turkey Creek about 100 yards from the mill. This well furnishes an abundanc of water all the year around at a depth of 14 to 30 feet. A short drift from the well shaft beneath Turkey Creek intercepts the creek underflow. The water pumped from the mine is not impounded, although plans have been made for its use for milling purposes.

Power is purchased from the Arizona Power Co., which serves a large portion of northern Arizona. The power rate is 1½ cents per kilowatt-hour, with a standard demand charge of $5 per horsepower for the first 25 hp. and $3 per horsepower thereafter. A refund of 15 percent of the monthly power bill is given on a deposit, which was made to the power company, for the construction of a 6-mile power line. The power is transmitted at 17,000 volts; it is stepped down at the property to 440-volt, three-phase, 60-cycle current for operating mine and mill motors and to 110 volts for mine lighting and domestic purposes. The cost of lighting the mine by electricity is one half that of lighting by carbide lamps.

Fuel for heating and domestic purposes is obtained on the premises. There is no timber suitable for mining purposes, however; mine timbers must be shipped in, but as the ground stands well, the minimum of timbering is required.

GENERAL GEOLOGICAL FEATURES

The predominant rocks of the district are Yavapai or pre-Cambrian schist and Bradshaw granite cut by dikes of porphyry, diabase, diorite, and quartz. The general formation at the Golden Belt mine is schist; the dip of the schistosity is vertical and the strike north and south. The schist is cut by dikes of rhyolite porphyry and altered diabase.

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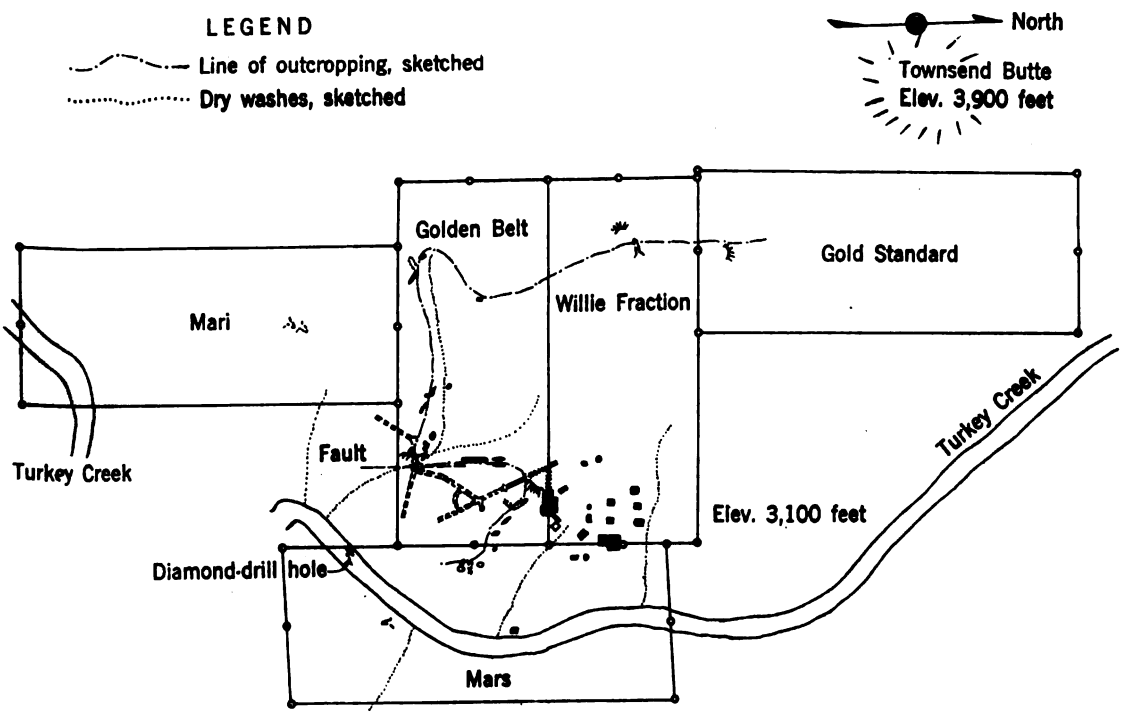

Figure 1.—Golden Belt group of claims.

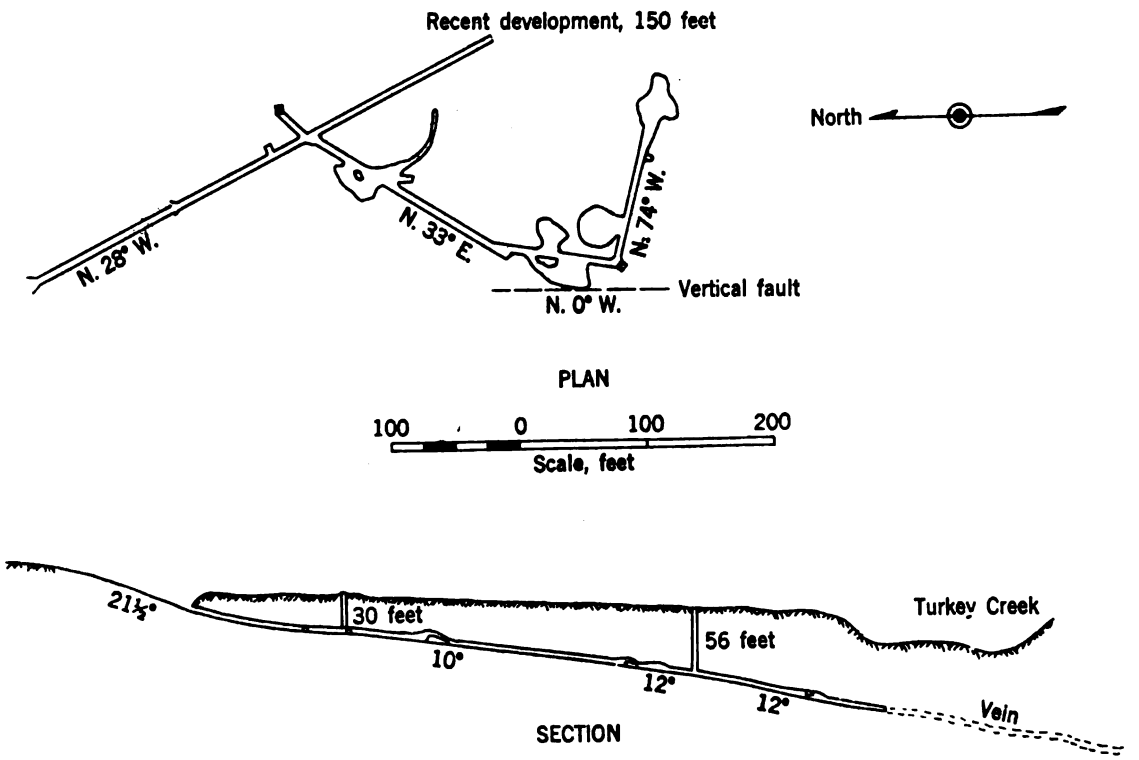

Figure 2.—Plan and section of Golden Belt incline.

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The vein is a fissure with a dip varying from 10° to 23°. The strike is about N. 60° E. There is evidence to show that the ore has been deposited in the fissure vein along a thrust fault and in the accompanying shear zone. The fault cuts the schist obliquely, leaving occasional "horses" of country rock in the shear zone. The zone varies in width from 6 inches where it cuts the diabase to 8 feet where it is in the porphyry. The outcrops can be traced on the surface for approximately 1,800 feet.

Figure 1 shows the five unpatented claims, the camp, underground workings, and a dotted sketch of open-cut and surface workings along the outcropping of the vein. According to Lindgren:[3]

> About 2 miles east of Turkey Creek station, in the flat at an altitude of 3,100 feet, are numerous openings on several very flat quartz veins. The country rock is schist, and the veins cut squarely across the schistosity. These veins are said to extend up to Dripping Springs on the north. They are as much as 6 inches wide and are formed of quartz filling with excellent comb structure and a little pyrite and galena. Some of this ore is said to contain $100 in gold to the ton. Much mining has been done on a small scale, and a considerable amount of ore has been shipped. .....

The quartz vein on the Golden Belt property varies in width from a few inches to 3 feet and carries from $5 to $40 in gold per ton and from 1 to 10 ounces of silver. In the upper portions of the mine, above the water level, the vein is highly oxidized and contains the oxides of iron and lead and some free gold. The average value of this ore as determined from several engineers' reports is $10.50 per ton. Below the water level or 50 feet below the surface the ore is almost entirely sulphide and is composed of auriferous pyrite and galena. The galena carries the greater part of the gold. Mill-head assays show the silver to be decreasing as depth is attained. No free gold has been found in the sulphide ore. The schist and porphyry carry finely disseminated pyrite both above and below the vein for a distance of a few inches to several feet. These finely disseminated sulphides carry but little gold or silver; the precious metals seem to be contained in the massive sulphide.

PROSPECTING AND DEVELOPMENT

The outcrops of the vein have been developed by open-cuts, trenches, and adits. A single diamond-drill hole has been drilled 230 feet in advance of the lowest face on the incline. This hole intercepted the "blanket vein" at a depth of 80 to 95 feet and indicated that it was continuous. As the schist is too easily fractured to core well and the vein matter too friable, little core was obtained; however, the cuttings which were saved showed heavy sulphide minerals in the last 3 feet of the hole and a smaller amount of sulphide

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3 Lindgren, Waldemar, Ore Deposits of the Jerome and Bradshaw Mountains Quadrangle, Ariz.: U. S. Geol. Survey Bull. 782, 1926, p. 158.

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from the preceding 12 feet. Assays of this sludge were not considered representative, as some of the drilling water was lost and undoubtedly carried away some of the heavier sulphide cuttings. The diamond drilling was done by the company at a cost of approximately $1 per foot; bortz was used as a cutting medium. A used portable Bravo diamond-drilling machine equipped with an Overland gasoline engine was lent to the company.

Until the past few months the development of the vein has consisted of extending the incline, turning indiscriminately to follow the ore but continuing down on the vein. As a result, the incline shaft zigzags its way along the vein for a distance of about 675 feet. On account of the turns and the variation in grade, rollers have been set on the ties, on stulls at the side walls or across the back, to reduce the friction in hoisting and to prolong the life of the cable. The stulls also carry the light and signal-bell wires. The shaft averages 6 by 6 feet in size and is not timbered except at the portal.

Recently an incline has been sunk 150 feet on a dip of 14°, extending the upper part of the shaft in a straight line (fig. 2). The work was done in 1 month, at the rate of one shift per day; drilling and shoveling were done at different times to present a clean face for drilling to prevent increasing the power demand by running the compressor and hoist at the same time. No water was encountered in sinking.

The following tabulation shows the cost of this work. The expense of hoisting equipment, air equipment, tools, and supervision is not included.

Cost of sinking 150 feet of shaft

Labor:	
2 muckers at $74 per month	$148.00
1 miner (foreman) at $124 per month	124.00
1 hoistman at $74 per month	74.00
2 surface men at $74 per month; sharpening steel, hauling supplies, making repairs, etc.	148.00
Power:	
Hoist, air compression, lighting, etc.	100.00
Powder, fuse, and caps	277.50
Supplies:	
Spikes, rails, ties, etc.	50.00
Insurance	11.24
Costs:	
Total for 150 feet of shaft	932.74
Total cost per foot	6.22
Labor	3.29
Explosives	1.85
Power, supplies, etc.	1.08

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Detailed costs of all other sinking, drifting, raising, and stoping are not available but are included in the totals in the summary at the end of the paper.

STOPING

No definite system of mining can be decided upon until the flat vein can be traced and the extent of the orebodies determined. There has been no systematic plan of stoping; ore has been stoped only to furnish material to the mill and to prevent suspension of operations when water has delayed progress in the incline. The relatively small amount of ore mined separately from development work has been taken out by an open-stope method. The stopes are very flat and average about 5 feet in height. The ore is shoveled by hand from turn sheets into mine cars; part of it must be shoveled twice. The ground stands very well; 8- by 8-inch stulls are used where needed for support in the stopes. Both in the incline and in the stopes an attempt is made to blast the ore and waste separately so that sorting will be unnecessary. Drilling is done by jackhammers mounted on columns with arms.

Scrapers will probably be used in stoping in the flat vein when the mine is put on regular production.

UNDERGROUND AND SURFACE HAULAGE

A single ¾-ton mine car controlled by the hoist is used for all haulage and hoisting. The hoist is a Novo P117 tugger powered by a low-speed 10-hp. motor with a circuit breaker. The hoist drum carries 800 feet of 3/8-inch, 9 by 16 plow-steel cable. The life of the cable is about 4 months and it costs about 10 cents per foot. The haulage incline is about 675 feet in length and the broken rock must be hoisted a vertical distance of about 145 feet. The car is hoisted to the surface at the rate of 4 to 6 trips per hour, requiring about 5 minutes to raise, dump, and return the car to the shovelers. At the hoisthouse the car is switched and lowered by gravity under control of the hoist to the mill crusher bin or to the waste dump. A headframe is not necessary.

VENTILATION AND DRAINAGE

Two raises to the surface (fig. 2) furnish ventilation; one contains a conduit for pipes from the pump and a power line to the pump motor. The first raise cuts the vein and incline at a point 117 feet from the portal and 30 feet below the surface; the second raise, which is 394 feet from the portal, is 56 feet to the surface.

The water level during wet weather was encountered at a depth of about 50 feet below the surface or about 343 feet down the incline from the portal. The fact that the incline dips beneath Turkey Creek may create a serious water problem as depth is attained.

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A 6- by 6-inch Gould Pyramid pump with a capacity of 50 gallons per minute and driven by a 5-hp. motor handles all water during the dry season. During wet weather, however, this pump and an American Well Works sinking pump with a rated capacity of 225 gallons per minute and 100 feet lift, driven by a 15-hp. motor, will not handle the flow of water with more than a 50-foot lift. As the bottom of the incline is more than 100 feet below the surface, the larger pump is useless for draining the lower part of the mine.

MILLING PLANT

Early activity on the property was along the line of experimentation in milling rather than of development of an orebody. Amalgamation, cyanidation, and concentration methods were attempted without success. A large part of the mill equipment used in this work was on the property when it was taken over by the present company, so that the cost of rebuilding the plant was not excessive.

The mill is a simple flotation plant of 50 tons maximum daily capacity, installed as a pilot mill to help defray costs of mine development. The operation is intermittent, depending on the mine development output. The ore is very amenable to treatment by flotation methods, and a concentrate is produced by a single rougher operation. For regular operation the milling plant should be augmented by a set of rolls to increase grinding capacity, a cleaner cell, increased ore and concentrate bin capacity, and a thickener for the concentrate pulp before filtration. At present the mill lacks flexibility, which results in intermittent operation and higher operating costs.

The general flow sheet of the mill is presented in figure 3. The building is constructed of galvanized iron and timber, with concrete foundations for the machines. The air-compression equipment for the mine is also housed in the mill building and is tended by the mill operator. All machines are individually motor-driven and require a running load of approximately 47 hp. The following tabulation shows the power requirements of the various units.

Operation	Horsepower load (estimated)	Kilowatt-hours per ton	Percent of total
Breaking	5	1.5	10.6
Grinding	30	18.2	63.9
Classifying and feeding	2	1.2	4.3
Flotation	4	2.4	8.5
Filtering	4	2.4	8.5
Water supply	1½	.9	3.2
Miscellaneous ...	½	.3	1.0
Totals	47	26.9	100.0

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The above data are based on the treatment of 725 tons of ore in 39 days of operation, the daily operation averaging 15 hours. The breaker is run approximately one half the time of mill operation.

EQUIPMENT AND COSTS

As stated before, some development work had been done and some equipment was on the ground when the present company took over the property. An appraisal has been made of the value of this development work and equipment as of May 1, 1931. The figures are shown in the accompanying tabulation. The cost of new equipment, amount and cost of new development, milling costs, transportation, overhead, and total costs are also shown in the tabulations.

Cost of equipment

Camp:		
Roads	$ 100.00	
Camp buildings:		
Six 3-man bunk houses, 3-room manager's quarters with bath, dining room and kitchen, office, storehouse, and 2 latrines	2,300.00	
Mine buildings:		
Small hoist house, blacksmith shop, and powder house	200.00	
Total roads, camp, and mine buildings	2,600.00	
Camp equipment:		
Furnishings for bunk houses, manager's quarters, office, dining room, kitchen, etc., with electric refrigeration and washing machine and radio	3,507.00	
Total cost of camp		$6,107.00
Mine:		
Blacksmith-shop equipment:		
Blower, anvil, tank, and tools	100.00	
Assaying equipment and supplies:		
Gasoline furnace, balances, etc.	418.34	
Drilling equipment:		
2 jackhammers with air and water hose and fittings, 41-inch column, 54-inch column, and arm and collar	500.00	
Hoisting equipment:		
1 Novo tugger driven by 10-hp., 950-r.p.m. motor with circuit breaker	150.00	
2 ore cars, 1/2- to 3/4-ton capacity	70.00	
800 feet of 3/8-inch, 9 by 16 plow-steel cable (new)	80.00	

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Cost of equipment - Continued

Mine (Cont'd):		
Air-compression equipment:		
1 Ingersoll Rand 7 by 6 class ER1 compressor with receiver and fittings	$ 202.00	
Motor for compressor	25.00	
Pumping equipment:		
1 6 by 6 Gould Pyramid pump, chain driven by 5-hp. motor, capacity 25 gal. per min.	226.00	
1 American well works sinker, capacity 225 gal. per min., maximum head 100 feet, mounted on car wheels, driven by 15-hp. motor with starter	632.00	
Miscellaneous	100.00	
Total mine equipment		$2,503.34
Mill:		
Building, including ore bin and concentrate bin	2,850.00	
Crushing equipment:		
1, 7- by 10-inch Blake type crusher driven by 10-hp. motor with starter	275.00	
Grizzly, 6 by 3 feet	25.00	
Ore feeder, 30-inch Challenge	100.00	
Ball mill, 5 by 4 feet, with clutch, driven by 30-hp. motor with starter	425.00	
Balls and liners	502.00	
Chain drag classifier, 15 feet by 22 inches, driven by 3-hp. motor which also drives ore feeder and reagent feeder	185.00	
Flotation equipment:		
Single rougher cell	190.00	
Blower:		
Connersville, 285 cubic feet per minute capacity, driven by 10-hp. motor	222.00	
Filter:		
1- by 4-foot Dorrco, including reduction gear, 1½-hp. motor, and vacuum pump with 5-hp. motor	1,125.00	
Water-supply lift pump, V-belt driven by 3-hp. motor	100.00	
Miscellaneous equipment, including reagent feeder and tanks, drive belts, launders, piping, wiring, line shafting and bearings, tools, foundations, etc.	1,688.00	
Total cost of mill equipment		1/ 7,687.00
Transportation:		
Truck	950.00	950.00
Total cost of equipment		17,247.34

1/ Includes $316.35 for repairs of equipment off property.

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Cost of operation

Development:		
Labor:		
Open cuts, 750 linear feet (estimated)		
Tunnels and drifts, 598 linear feet (estimated)		
Raises, 95 linear feet		
Incline shaft, 825 linear feet		
Direct labor including $24 per month for board and room, per man	$13,196.15	
Repairs off property	142.95	
Total labor cost		$13,339.10
Supplies:		
Powder, fuse, and caps	1,324.90	
Miscellaneous equipment, tools, and supplies	2,064.84	
Total cost of supplies		3,389.74
Power (mine only)	795.06	795.06
Total development cost		17,523.90
Transportation:		
Supplies and repairs for truck or automobile	998.50	
Truck driver including hauling 258 tons of concentrates	193.50	
Total cost of transportation		1,192.00
Milling:		
Labor for milling 2,370 tons of ore, including mill-construction costs	3,023.88	
Power 1/	1,590.12	
Supplies 2/		
Total milling cost		4,614.00
Overhead:		
Supervision expenses	1,354.81	
Insurance with Industrial Commission	405.41	
Organization expenses (legal)	108.50	
Office expenses	61.50	
Survey of property	144.00	
Miscellaneous expenses	2,390.07	
Total overhead costs		4,464.29

1/ Mill power costs appears excessive because intermittent operation creates a high power demand cost.

2/ Supply costs included with equipment.

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Summary of Costs

	Appraised value as taken over May 1, 1931	Disbursements to April 1, 1932	Total
Camps:			
Buildings	$2,000.00	$ 500.00	$2,500.00
Equipment and supplies	2,755.00	752.00	3,507.00
Roads	100.00	-	100.00
Totals	4,855.00	1,252.00	6,107.00
Mines:			
Equipment and supplies	3,362.00	2,531.08	5,893.08
Development:			
Direct labor and repairs.	6,876.00	6,320.15	13,196.15
Repairs off property	-	142.95	142.95
Power	-	795.06	795.06
Totals	10,238.00	9,789.24	20,027.24
Transportation:			
Truck	100.00	850.00	950.00
Labor and supplies	-	1,192.00	1,192.00
Totals	100.00	2,042.00	2,142.00
Mill:			
Buildings and bins	2,800.00	50.00	2,850.00
Equipment and supplies	2,855.00	1,666.15	4,521.15
Repairs off property	-	316.35	316.35
Labor, construction, and milling	-	3,023.88	3,023.88
Power	-	1,590.12	1,590.12
Totals	5,655.00	6,646.50	12,301.50
Overhead	1,100.00	3,364.29	4,464.29
Total costs	21,948.00	23,094.03	45,042.63

Smelter returns

The net smelter returns during the development were as follows:

Crude ore	106 tons	$ 891.49
Concentrates	285 tons	8,523.63
Total		9,415.12

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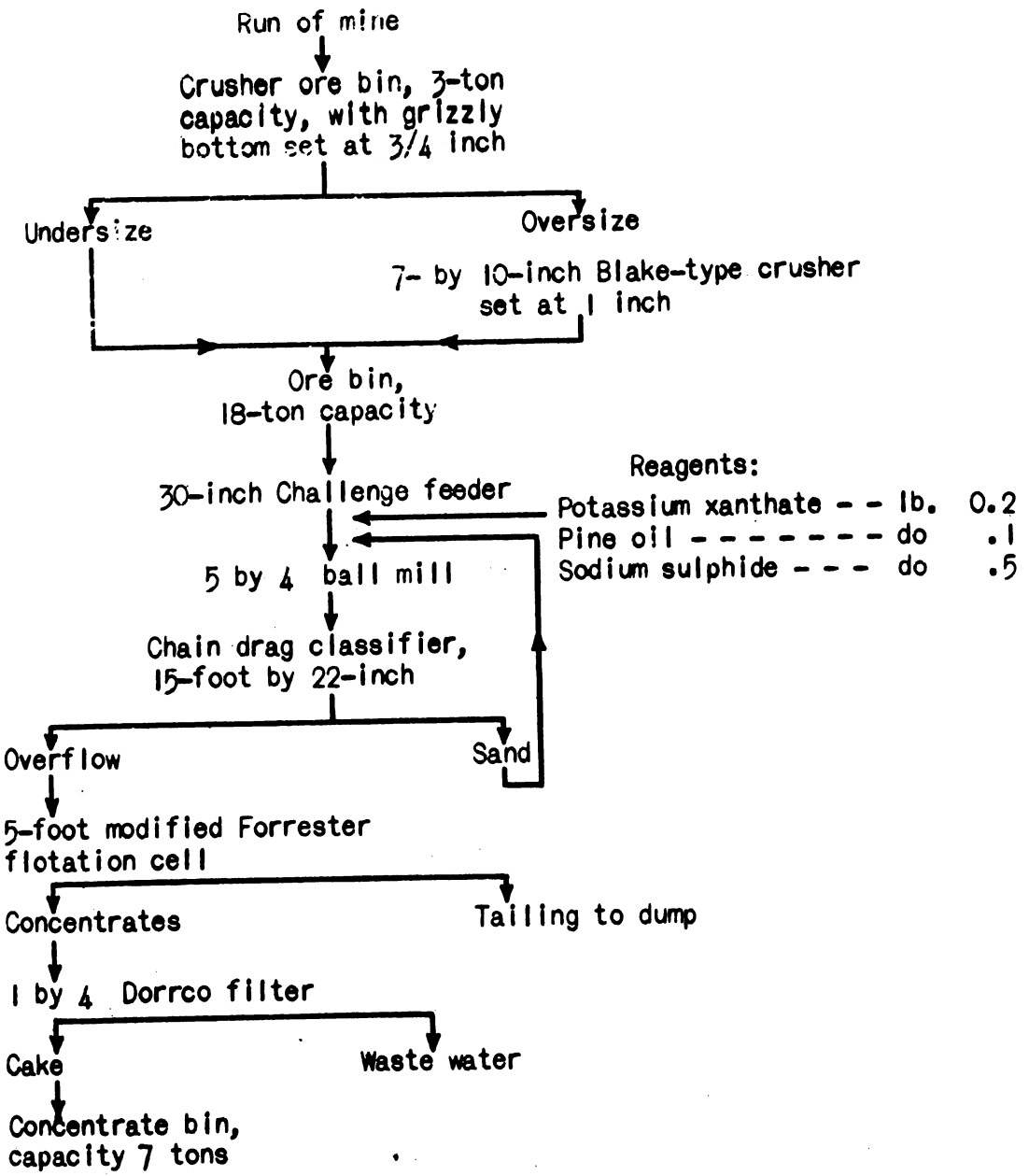
Run of mine
Crusher ore bin, 3-ton capacity, with grizzly bottom set at 3/4 inch
Undersize
Oversize
7- by 10-inch Blake-type crusher set at 1 inch
Ore bin, 18-ton capacity
30-inch Challenge feeder
Reagents:
Potassium xanthate - - lb. 0.2
Pine oil - - - - - - - - do .1
Sodium sulphide - - - do .5
5 by 4 ball mill
Chain drag classifier, 15-foot by 22-inch
Overflow
Sand
5-foot modified Forrester flotation cell
Concentrates
Tailing to dump
1 by 4 Dorrco filter
Cake
Waste water
Concentrate bin, capacity 7 tons

Figure 3.- Flow sheet of mill.

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